Effect of Phosphorus and Biofertilizers on Growth and Yield of Chickpea (*Cicer arietinum* L.)

ABSTRACT

A field experiment was carried out during *rabi* season of 2022 on Chickpea crop at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P India). The soil of the experimental plot was Sandy loam in texture, with a pH 7.2, that was neutral with EC- 0.26 (dS/m), organic carbon (0.72%), available N (178.48kg/ha), available P (27.80kg/ha) and available K (233.24kg/ha). The treatments consisted of 3 levels of Phosphorus (40, 50 and 60kg/ha) and Biofertilizers (*Rhizobium sp.*, *Pseudomonas striata*, PSB) and a control. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and replicated thrice. The present investigation was carried to find out "Effect of Phosphorus and Biofertilizers on Growth and Yield of Chickpea (*Cicer arietinum* L.). Application of Phosphorus 60kg/ha + PSB produced higher plant height (52.56 cm), No. of nodules/plant (23.03), dry weight (8.19g), No. of pods/plant (30.90), No. of seeds/pod (1.53), seed yield (2570.74kg/ha) and stover yield (3583.33kg/ha) in Chickpea.

Keywords: Biofertilizers, Chickpea, PSB, Rhizobium, Pseudomonas striata, Yield, Rabi.

1. INTRODUCTION

"Chickpea (*Cicer arietinum* L.) is the major pulse crop of India. At global level, it ranks fifth in terms of area and production under legumes. It is grown with less care and low manurial requirement. The productivity of chickpea is low because of its cultivation generally in poor soils. Pulses have inherent capacity to fix atmospheric nitrogen in symbiotic association with *Rhizobium*. This characteristic of pulses has helped in maintaining the sustainable fertility levels of soils. Under the pulses the soil does not allow water to run very fast which enhance the soil productivity, especially in case of the dry farming zones. Because of their better ground coverage, the pulses reduce water losses through evaporation from the soil surface. Application of phosphorus increased the production of pulse crops" [1]. "Pulses occupy a unique position in every known systems of farming all over the world. Among pulses chickpea (*Cicer arietinum* L.), the premier pulse crop of India, popularly known as Gram or Bengal gram is mainly grown in *rabi* season. It is the member of family Leguminoceae and subfamily Papilionaceae. Chickpea is a rich source of highly digestible dietary protein (17-21 per cent), carbohydrate (61.5 per cent) and fat (4.5 per cent). It is also rich in Ca, Fe, niacin, vitamin-B and vitamin C. Its leaves contain malic acid which is very useful for stomach ailments and blood purification. It is being a pulse crop that enriches the soil through symbiotic nitrogen fixation" [2]. "Chickpea is classified into two types, desi and kabuli. Desi types are small in size, angular in shape with brown seed colour and hard seed coat. Desi chickpea is primarily grown in the semi-arid tropical climates, while kabuli are white seed coat colour and larger in size with smoother seed coat. Kabuli chickpea is primarily grown in the temperate climates. Chickpea also plays an important role in sustaining soil productivity by improving its physical, chemical and biological properties and trapping atmospheric nitrogen in their root nodules" [3]. "India is the leading producer of chickpea contributing to about 70% of the world's chickpea production. In India, Madhya Pradesh (39%), Maharashtra (14%), Rajasthan (14%), Uttar Pradesh (7%), Karnataka (6%), and Gujarat (5%) are the major chickpea growing states. In India pulses are grown nearly in 28.83 m ha with an annual production of 25.72 m t and productivity of 0.8 t ha. Some of the states like Uttar Pradesh is about 8.24 m ha with an annual production of 9.97 m t and productivity of 1.08 t ha major producer of chickpea in India as advocated by Ministry of Agriculture and Farmers Welfare". [4]

"Phosphorus has been recognized as one of the important elements in plant nutrition. Phosphorus is an important nutrient especially for pulses to enhance their productivity. Phosphorus stimulates early root development, leaf size, tillering, flowering, grain yield and hastens maturity. It is a constituent of certain nucleic acids, that is, phospholipids, chromosomes and the coenzymes nicotinamide adenine dineucleotide (NAD) and nicotinamide adenine dineucleotide phosphate (NADP). Phosphorus is essential for cell division, seed and fruit development. A range of research experiments were conducted towards defining its chemistry in the soil – plant system. Soils are known to vary widely in their capacity to supply P to crops, as only a small fraction of it in soil solution is in available form to crops".[2] "Application of phosphorus increased the production of pulse crops" [1]**.** "The response of phosphorus depends upon many factors like climate, variety and soil type and availability of nutrients during the period of growth. The requirement of phosphorus in legumes like chickpea is higher than other crops for their root development and metabolic activities. Phosphorus is the vital component of DNA, RNA, ATP and photosynthetic system and cetalyzes a number of biochemical reactions from the beginning of seedling growth through to the formation of grain at maturity" [5].

"Biofertilizers are preparations containing living cells or latent cells of efficient strains of microorganisms, which when applied through seed or soil treatment, promote plant growth by increasing the nutrient acquisition to the host plant. These help in enhancing biological nitrogen fixation through promotion of nodule formation, phosphorus solubilisation, production of phytohormones like cytokinins, gibberellins and indole acetic acid (IAA)" [6]. **"**Biofertilizers may colonizes the rhizosphere and promotes growth by increasing the availability and supply of nutrients and growth stimulus to crop. Nitrogen fixer and phosphate solubilizing microorganisms play an important role in supplementing nitrogen and phosphorus to the plant, allowing a sustainable use of nitrogen and phosphate fertilizers. Some important strains are mentioned as plant growth promoting rhizobacteria (PGPR) and that can be used as biofertilizers i.e., *Rhizobium*, *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Bacillus*, *Burkholdaria, Erwinia*, *Mycobacterium*, *Flavobacterium* etc" [7]. **"**Phosphate solubilizing bacteria, when inoculated, secret acidic substances and solubilize otherwise unavailable soil phosphorus. The culture can hence prove broad spectrum biofertilizers which may increase yield of crops (Legumes, vegetables etc) by 10-30%. Use of Phosphate Solubilizing Bacteria culture increases nodulation, crop growth, nutrient uptake and crop yield" [8]. "Certain microorganisms such as phosphate solubilizing bacteria and fungi associated with the plant rhizosphere are known to convert insoluble inorganic phosphorus (P) into a soluble form that could be utilized by the plants" [9]. "Thus, adopting proper nutrient management practices in conjunction with PSB will help to improve the yield and quality of chickpea besides maintaining the soil fertility" [10].

Keeping the above points in view, the present investigation was carried to find out "Effect of Phosphorus and Biofertilizers on Growth and Yield of Chickpea (*Cicer arietinum* L.)

2. MATERIAL AND METHODS

The experiment was carried out during *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) which is located at 25.39"42" N latitude, 81.50"56" E longitude, and 98m altitude above the mean sea level. This area is situated on the right side of the river Yamuna and by the opposite side of Prayagraj City. All the facilities required for crop cultivation were available. The soil of the experimental field constituting a part of central Gangetic alluvial is neutral and deep. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorus, and low in potassium. Nutrient sources were urea, and Muriate of Potash to fulfil the requirement of Nitrogen and Potassium. The phosphorus was applied in 40, 50, and 60 kg/ha through Single Super Phosphate nutrient source. The crop was sown on 5th November 2022. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice viz.,

Table 1. Treatment combination

S. No.	Treatment combination
1.	Phosphorus 40kg/ha + *Rhizobium sp.*
2.	Phosphorus 40kg/ha + *Pseudomonas striata*
3.	Phosphorus 40kg/ha + PSB
4.	Phosphorus 50kg/ha + *Rhizobium sp.*
5.	Phosphorus 50kg/ha + *Pseudomonas striata*
6.	Phosphorus 50kg/ha + PSB
7.	Phosphorus 60kg/ha + *Rhizobium sp.*
8.	Phosphorus 60kg/ha + *Pseudomonas striata*
9.	Phosphorus 60kg/ha + PSB
10.	Control (20-50-20 NPK kg/ha)

Blanket application of a recommended dose of fertilizers was done at the time of sowing. Biofertilizers (*Rhizobium sp.* at 5g/kg seed, Pseudomonas striata 10g/kg seed, PSB at 20g/kg seed) phosphorus levels are (40, 50, 60kg/ha) was applied as soil application along with blanket application of fertilizers before sowing. The growth parameters reading such as plant height (cm), nodules/plant (No.), plant dry weight (g) and also, yield parameters such as number of pods/plant, number of seeds/pod, seed yield (kg/ha), and stover yield (kg/ha). The growth parameters were recorded at an intervals of 20, 40, 60, 80, 100 DAS and at harvest stage, from the randomly selected five plants in each treatment. Statistically analysis was done using all the parameters in one-way Anova and means were compared at 0.05 probability level of significant results.

3. RESULTS AND DISCUSSION

3.1. Influence of phosphorus and biofertilizers on growth attributes of chickpea.

3.1.1. Plant height (cm)

Significantly highest plant height (52.56cm) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 2). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. The application of Phosphorus 60kg/ha + PSB resulted in significantly superior plant height to the rest of the treatments. The increase in plant height may be owing to the improvement in vigour of plants possibly by balanced supply and higher uptake of nitrogen and phosphorus. Similar findings were reported by Chauhan and Raghav

[11]. Increment in plant height may be due to increased uptake of nitrogen and phosphorus by the plants, which was made available through N fixation and P solubilization by the beneficial microorganisms. The results were also found in accordance with Singh *et al.* [12].

3.1.2. Nodules/plant (No.)

Significantly highest number of nodules/plant (23.08) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 2). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. "The increased in number of nodules per plant with phosphorus application could be because of P is required for plant growth, nodule formation and development, each process being vital for N_2 fixation. Phosphorus is known to initiate nodule formation". [13]. **"**Phosphorus is an essential nutrient for grain legumes, as it helps in improving nodulation and nitrogen fixation. Growth promotional activities of PSB through production of growth promoting substances and proliferation of beneficial organisms in the rhizosphere might have also improved growth characters and nodulation". [11].

3.1.3. Dry weight (g/plant)

Significantly maximum dry weight (8.19g) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 2). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. Phosphorus being an energy bond compound and its major role in transformation of energy essential for almost all metabolic processes *viz.,* photosynthesis, respiration, cell elongation and cell division, activation of amino acids for synthesis of protein and carbohydrates metabolism which ultimately increase all the growth attributes and dry weight of plants. Similar results have also been reported by Singh et al [12]. The seed inoculation with PSB improved the dry matter accumulation as compared to uninoculated treatment. This might be due to production of growth hormones such as Indole Acetic Acid (IAA) and Gibberellic Acid (GA_3) by PSB and solubilization of insoluble phosphate, which may favor the growth characters. The results were found in accordance with Meena *et al.* [14].

Table 2. Influence of phosphorus and biofertilizers on growth attributes of chickpea.

S.No.	Treatments	Plant height (cm)	Number of nodules/plant	Dry weight (g/plant)
1.	Phosphorus 40kg/ha + *Rhizobium sp.*	46.33	18.62	6.30
2.	Phosphorus 40kg/ha + *Pseudomonas striata*	46.08	18.34	6.17
3.	Phosphorus 40kg/ha + PSB	48.16	20.80	6.61
4.	Phosphorus 50kg/ha + *Rhizobium sp.*	47.21	20.53	6.45
5.	Phosphorus 50kg/ha + *Pseudomonas striata*	46.13	19.90	6.40
6.	Phosphorus 50kg/ha + PSB	50.06	22.07	7.98
7.	Phosphorus 60kg/ha + *Rhizobium sp.*	48.56	21.03	6.92

8.	Phosphorus 60kg/ha + *Pseudomonas striata*	48.10	20.37	6.52
9.	Phosphorus 60kg/ha + PSB	52.56	23.03	8.19
10.	Control (20-50-20 NPK kg/ha)	45.37	16.10	6.07
	F test	S	S	S
	SEm(±)	1.13	0.58	0.19
	CD (p=0.05)	4.12	1.72	0.58

3.2. Influence of phosphorus and biofertilizers on yield attributes and yield of chickpea.

3.2.1. Number of pods/plant

Significantly highest number of pods/plant (30.90) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 3). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. Combined application of P 60 kg/ha and biofertilizers increased the number of pods per plant. The regulatory function of phosphorus in photosynthesis and carbohydrate metabolism of leaves can be considered to be one of major factor limiting growth particularly during the reproductive phase. Similar result has also been reported by Das *et al.* [8]. In terms of number of pods per plant, higher values were found in inoculated than in uninoculated treatments. This finding was similar to those of N. Bildirici [15]

3.2.2. Number of seeds/pod

Significantly highest number of seeds/pod (1.53) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 3). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. “Application of phosphorus had significantly influenced the seed yield of chickpea over the control. The increases in seed yield with 60 kg P_2O_5 alone over the control were recorded to the tune of 42.7 and 38.3% respectively. The increase in yield with P levels can be attributed to the effective metabolic activities coupled with increased rate of photosynthesis, leading to better translocation of nutrients and expression of development characters”. [11].

3.2.3 Seed yield (kg/ha)

Significantly highest seed yield (2570.74kg/ha) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 3). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. “The application of increasing levels of phosphorus significantly increased the grain yield, which might be due to the active biotic role of phosphorus in metabolic processes of plants and photosynthesis and tended to increase flowering, fruiting and grain formulation which ultimately increased the yield attributes and yield. The increase in grain yield due to phosphorus seems to be due to the cumulative effect of yield attributes and possibly is a result of effective uptake and utilization of nutrient observed through its intensive root system developed under adequate phosphorus supply”. [16]. Phosphate solubilizing bacteria solubilised the applied and native unavailable phosphorus into readily available form resulting, improved the growth and yield attributes and finally yields of chickpea. The effect of inoculation on seed yield of chickpea was found to be important. This finding was similar to those of N. Bildirici [15]

3.2.4. Stover yield (kg/ha)

Significantly highest stover yield (3583.33kg/ha) was observed in treatment 9 (Phosphorus 60kg/ha + PSB) (Table 3). However, treatment 6 (Phosphorus 50kg/ha + PSB) was statistically at par with treatment 9. Phosphorus application accelerated the production of photosynthesis and their translocation from source to sink, which ultimately gave the higher values of stover yield. The increase in yield with biofertilizers was mainly due to the increase in almost all growth and yield contributing characters, which ultimately resulted a significant increase in stover yield. This was mainly due to fact that the better availability of N and P caused well developed root system having higher nitrogen fixing capacity resulting better growth and development of plants and better diversion of photosynthesis towards sink. The result of the present investigation are in close conformity with Singh *et al.* [12]. PSB produces growth substances like IAA & GA and also helps for formation of growth hormones which promotes seed maturation. This could be reason for increased stover yield of chickpea. Similar findings was reported by Laharia *et al.* [17]

Table 3. Influence of phosphorus and biofertilizers on yield attributes and yield of chickpea.

S.No.	Treatments	No. of pods/plant	No. of seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)
1.	Phosphorus 40kg/ha + *Rhizobium sp.*	26.27	1.13	1521.34	2606.67
2.	Phosphorus 40kg/ha + *Pseudomonas striata*	25.90	1.13	1465.56	2570.00
3.	Phosphorus 40kg/ha + PSB	28.07	1.20	1758.56	2983.33
4.	Phosphorus 50kg/ha + *Rhizobium sp.*	27.30	1.20	1658.17	2783.33
5.	Phosphorus 50kg/ha + *Pseudomonas striata*	26.87	1.13	1533.27	2746.67
6.	Phosphorus 50kg/ha + PSB	28.53	1.47	2276.39	3470.00
7.	Phosphorus 60kg/ha + *Rhizobium sp.*	28.10	1.33	1975.50	3256.67
8.	Phosphorus 60kg/ha + *Pseudomonas striata*	27.70	1.20	1701.20	2836.67
9.	Phosphorus 60kg/ha + PSB	30.90	1.53	2570.74	3583.33
10.	Control (20-50-20 NPK kg/ha)	25.13	1.13	1396.27	2496.67
	F test	S	S	S	S
	SEm(±)	0.93	0.05	101.85	79.42
	CD (p=0.05)	2.77	0.16	302.63	235.99

4. CONCLUSION

It is concluded that application of Phosphorus 60kg/ha along with PSB recorded highest growth attributes and seed yield in chickpea crop.

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